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Transit Investment Impacts on Land Use Beyond the Half-Mile Mark

A Research Report from the University of California Institute of Transportation Studies

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16. Abstract
This project examines the impacts of light rail transit investments on broader vicinity areas in Los Angeles County. This project found that the land use impacts of public transit investments are not necessarily confined to the half-mile boundary around station areas, although substantial variation exists by transit line. While the areas beyond the half-mile mark were often excluded from conventional transit-oriented planning processes, these areas show a distinct pattern of land use transformation. Areas beyond the half-mile mark had a higher rate of development for several urban purposes, particularly after a few years have elapsed since the opening of nearby transit lines/stations.

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UNIVERSITY OF CALIFORNIA INSTITUTE OF TRANSPORTATION STUDIES

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Executive Summary

While recent years have witnessed a growing interest in transit-oriented development (TOD) and other transit-centered initiatives as a core strategy for attaining the vision of California's Senate Bill 375, little is known about how investments in public transit systems modify urban land use patterns and the geographical extent of impacts. Prior research, although valuable, often fails to consider the heterogeneity of transit lines/stations in terms their development history, service quality, or other important attributes that could generate substantial variation in land use outcomes. Furthermore, little attention has been paid to the continuing expansion (or quality improvements) of a public transit system that can shape urban land use patterns over a long period of time. In practice, the well-known half-mile catchment areas around transit stations have been used widely to delineate the potential impact area. However, impacts beyond the half-mile radius boundaries remain understudied.

In this project, we challenge the traditional delineation of transit impact areas and analyze the impacts of light rail transit expansion on broader vicinity areas in Los Angeles County where the public transit system has expanded substantially over the last few decades. More specifically, building on a recently completed UCTC project, "Infill Dynamics in Rail Transit Corridors: Challenges and Prospects for Integrating Transportation and Land Use Planning", we investigate how land use change patterns vary with increasing distance from rail transit stations with a focus on both Near (<0.5 miles) and Farther (0.5-1.0 mile) areas around transit stations. This is mainly accomplished through a set of land use change frequency computations and multinomial logistic regression analyses.

Our analysis suggests that the land use impacts of transit investments are not necessarily confined to the half-mile boundary, although substantial variation exists by transit line. While the Farther areas (0.5-1.0 mile) remained single-family housing dominant in many cases and were often excluded from conventional transit-oriented planning processes, these areas experienced a distinct pattern of land use transformation. In particular, vacant parcels in these areas are found to be more rapidly developed not only for single-family residential but also open space purposes. Furthermore, Farther industrial sites are more likely to be redeveloped for multi-family housing, but such impacts are not detected for newly developed station areas.

Local policy/planning efforts also appear to matter. According to our analysis, local planning districts with pro-transit elements show an increased rate of industrial land conversion to multi-family housing and commercial uses, suggesting that more attention needs to be paid to the importance of systematic land use – transportation planning integration. Local planners and policy makers also need to think beyond traditional half-mile catchment areas and explore ways to refine transit-oriented development strategies based on a solid understanding of the complex mechanisms between transit investment and land use change dynamics in broader transit vicinity areas. This will eventually help to achieve the full vision of Senate Bill 375 and other sustainable development initiatives.

Introduction

Integrating land use and transportation has been increasingly placed high on the priority lists of many states and local/regional planning agencies. In particular, it has been widely presumed that transit investment can significantly contribute to curbing sprawl and creating a more compact (and thus more sustainable) pattern of urban land use, while providing a broader range of mode choice options. This notion/presumption – often supported by research – has led to a growing interest in transit-oriented development (TOD) and other transit-centered initiatives in the United States, including California in which TOD and associated planning actions have been increasingly implemented as a core strategy for attaining the vision of Senate Bill 375.

While a considerable number of studies have examined the land use impacts of public transit[1], still little is known about how our investment in public transit systems can actually modify urban land use patterns, under what circumstances the (favorable) impacts can be promoted, and to what (spatiotemporal) extent. Prior research, although valuable, tends to assume transit lines/stations as a homogeneous facility/amenity without explicit consideration of their history, service quality, and other attributes that could generate a significant difference in land use outcomes, although "rail transit corridors are not created equally, and transit providers and community planners should consider the social and development context of corridors in efforts to improve transit access and maximise development" (Houston et al., 2015, p.938). Furthermore, little attention has been paid to the continuing expansion (or quality improvements) of a transit system that can (re)shape land use patterns consistently over a long period of time. In practice, the well-known half-mile circles around transit stations have been used widely in delineating the potential impact area (see e.g., Canepa, 2007; Guerra et al., 2012). Available research, however, provides few insights into the impact of rail transit on land use beyond the half-mile circles; in response, this study is motivated to expand our understanding of the land use impacts of public transit investments in broader vicinity areas.

In a previous research project (Kim and Houston, 2016), we utilized a half-mile walking distance assumption to examine how rail transit investment/expansion was associated with land use changes in Los Angeles County. Building on the project, in this study, we assess the impacts of light rail investments on areas beyond the half-mile station radius and associated evolution of land use patterns in Southern California, where its public transit system has expanded over the last several decades and will continue to do so in the foreseeable future. By doing so, we attempt to better understand the complex mechanisms by which a transit system expansion shapes urban land use patterns and to enhance our ability to create a more sustainable form of urban development.

[1] See Huang (1996) or Vessali (1996) for a comprehensive review of early research on the relationship between transit and land use. Kim and Houston (2016) also provide a concise review of more recent studies.

Study Area

Over the last few decades, Southern California has undergone a dramatic expansion of its public transit system. In particular, a large amount of rail transit investments have been made in Los Angeles County, starting with the Metro Blue line opened in 1990 with 22 stations running from 7th St./Metro Ctr. to Long Beach. The rail transit system was augmented by the Red, Purple and Green lines throughout the 1990s. More recently, the Metro Gold and Expo lines have been added to the system to broaden the service area boundaries significantly. It should be noted that more system expansions will take place in the future (see LA Metro website, specifically https://www.metro.net/interactives/metrorail_timeline/).

Our previous project, titled "Infill Dynamics in Rail Transit Corridors: Challenges and Prospects for Integrating Transportation and Land Use Planning" (Kim and Houston, 2016), analyzed the impacts of the transit system expansions on land use change between 2001 and 2012 with a focus on the first phase of Metro's Gold Line which opened in 2003. Using a multinomial logistic model of urban land use change (which is employed in this study again), we found:

- A significant variation in land use outcomes across transit lines/stations existed, suggesting that various contextual factors (including transit ridership) do matter.
- Land parcels within walking distance of new transit stations were more likely to be developed for residential and other urban purposes, compared to those with limited transit accessibility.
- Transit investment appeared to function as a facilitator of industrial site redevelopment for multi-family residential and urban open space provision.

However, little attention was paid to the land use change dynamics beyond the half-mile station radius, while alternative transit area boundary lines were tested in a form of sensitivity analysis. Furthermore, it remains largely unanswered how various urban policies can shape the way transit investments facilitate infill development or reuse of urban properties. As shown in figure 1, the study region has had a range of spatially-explicit development policies, including the Federal Renewal Community Initiative (FRC), Federal Empowerment Zones (FEZ), State Enterprise Zones (SEZ), Business Improvement Districts (BID), and Targeted Neighborhood Initiative (TNI). Furthermore, multiple localities have implemented various plans to incentivize development of the areas surrounding transit stations (e.g., Pasadena's Central District Specific Plan).[2]

[2] We collected and analyzed the specific plan information along with the first phase of Metro's Gold Line, in the City of Los Angeles, the City of Pasadena, and the City of South Pasadena. In figure 1, Pro_SP refers to the plan area boundaries in which pro-transit elements are found (e.g., Old Pasadena A-2: Memorial Park Urban Village and Old Pasadena A-4: Old Pasadena Transit Village areas in Pasadena's Central District Specific Plan).

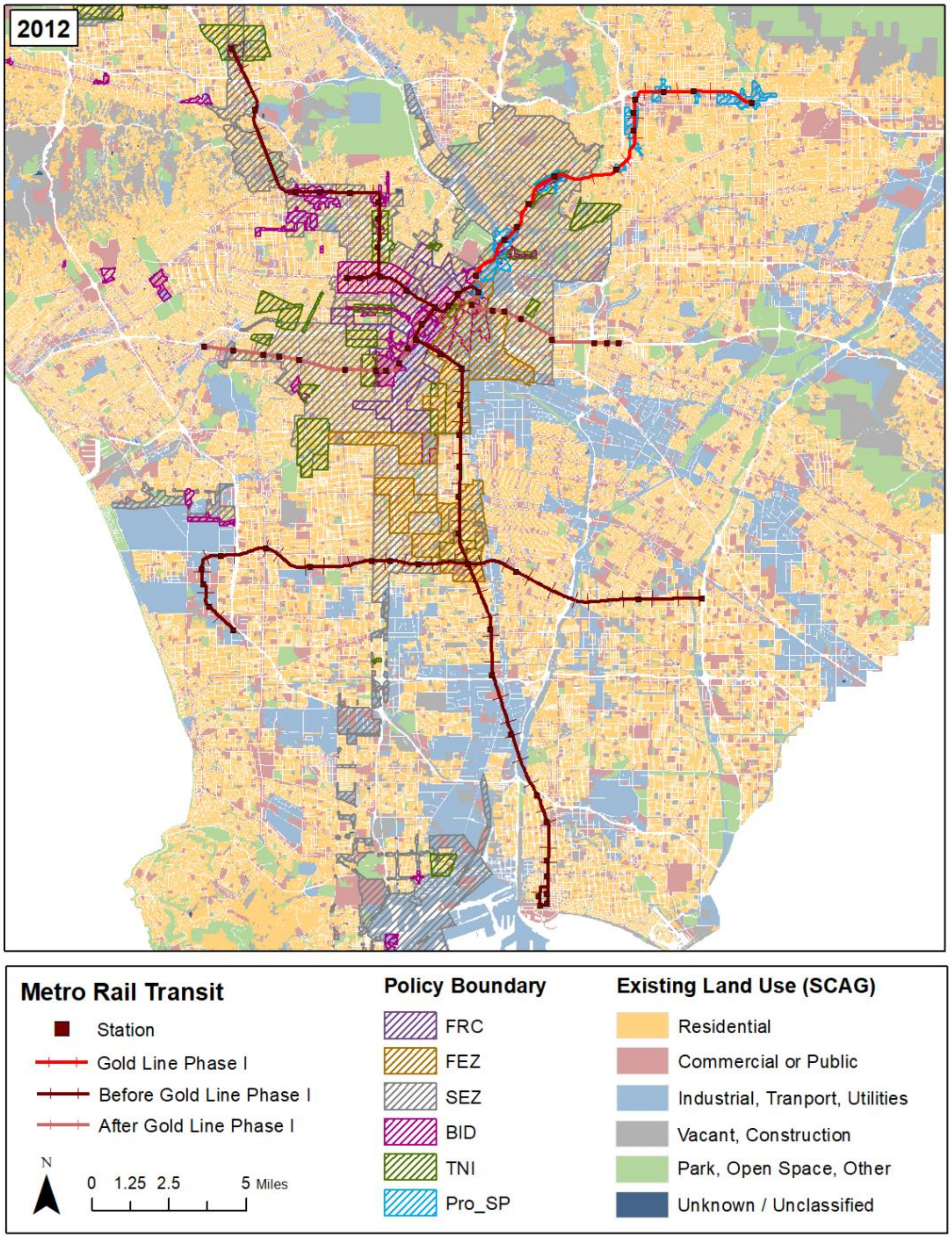

Figure 1 Study Area

Land Use Patterns near Transit Stations

First of all, to examine the relationship between land use and transit accessibility, we investigated how land use patterns vary with increasing distance from rail transit stations in Los Angeles County. More specifically, we analyzed the detailed composition of land use in ***Near*** and ***Farther*** areas, which refer to the land parcels within the half-mile radius boundaries and those falling between 0.5 and 1.0 mile rings, respectively (see figure 2 which provides an illustrative sample of the land use patterns near the Gold Line Sierra Madre Villa Station in Pasadena).

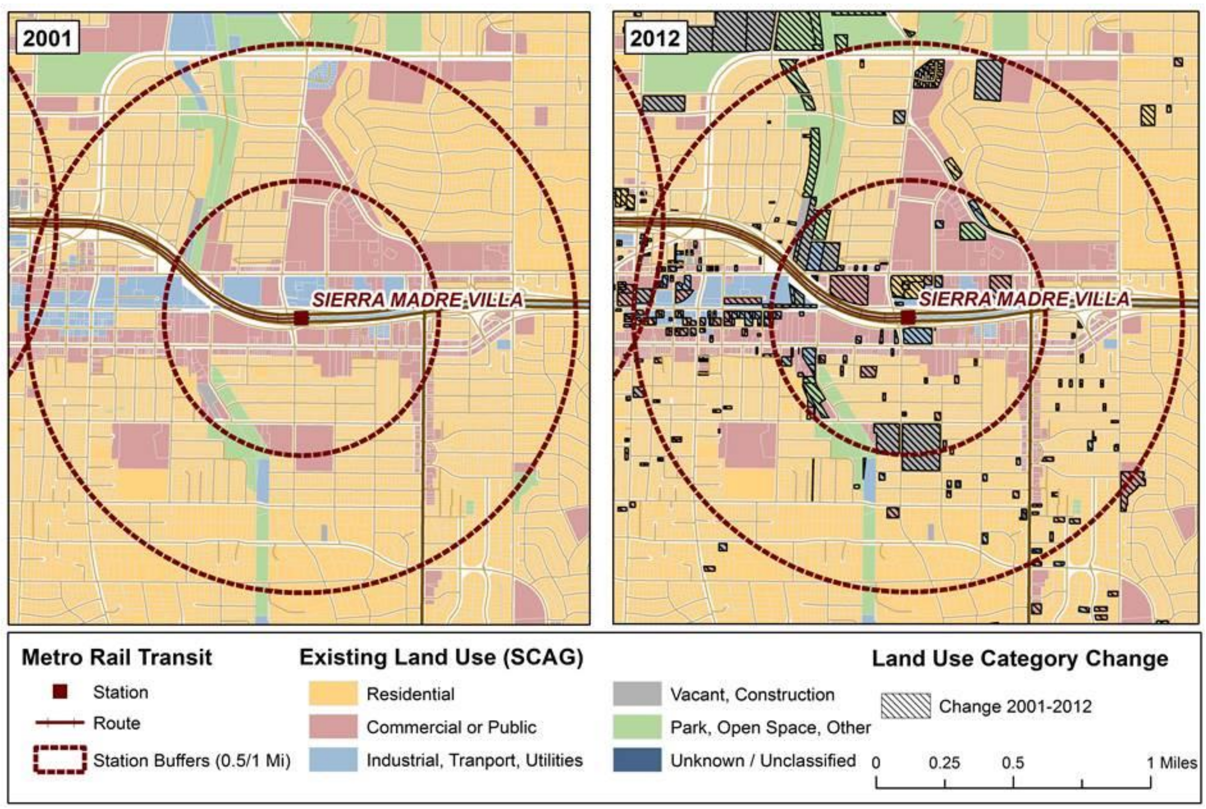

Figure 2 Broader Vicinity Areas

Overall, transit areas showed a distinct pattern of land use, compared with the county-wide averages. The proportion of single-family residential is lower not only in Near but Farther areas, while the gap tended to be smaller with a longer distance from transit stations. Instead, a relatively larger percentage of the areas was devoted to duplexes, townhouses, or other types of multi-family housing units. Commercial and industrial uses were also more likely to be found in these transit areas, while these activities tended to be concentrated within Near areas immediately adjacent to stations rather than Farther areas.

However, there was substantial variation in the land use distribution across transit lines/stations. For instance, in general, station areas near the first phase of Metro's Gold Line had a higher percentage of single family housing parcels compared to station areas near other lines. Approximately 65% of the parcels in Gold Line Phase-I Farther areas turned out be used for this purpose, while the percentage within Gold Line Phase-I Near areas was about 40%.

In the case of older stations opened before the Gold Line Phase-I (Blue, Red, Purple, and Green lines), single-family residential accounted for approximately 35% and 55% of the total parcels in Near and Farther areas, respectively. Around newer stations opened after the Gold Line Phase-I, the proportion of single-family residential fell between 40 and 45% in Farther areas. Instead, nearly 30% of the total parcels was classified into other types of residential (e.g., mobile homes, trailer parks, mixed residential). This pattern of land use composition could be attributed to the uniqueness of the Expo and the Gold Line Phase-II station locations. Given the composition, the degree of land use mix was relatively higher in these areas, compared to that of the areas around the Gold Line Phase-I.

Land Use Change Frequencies, 2001-2012

In addition, focusing on vacant parcels, we compared the frequencies of various types of development – 1. Single-family Residential, 2. Multi-family Residential, 3. TCIU (Transportation, Communications, Industrial/Commercial, and Utilities), and 4. (Urban) Open Space – in Near and Farther areas. We also investigated the frequencies of redevelopment of industrial sites between 2001 and 2012 to see how the land use change dynamics in Farther areas differ from those within Near areas or the county averages.

New Development of Vacant Parcels

Table 1 summarizes the frequencies of various types of new development in transit areas, compared to county averages. Approximately 29% of the vacant parcels in Farther areas were found to be developed between 2001 and 2012, which was a pace slightly more rapid than the county average, but slower than that of Near areas. Note that the comparable county average was 27.2%, and Near areas exhibited a 33.9% of new development frequency. Compared with Near areas, land parcels in Farther areas were more likely to be developed for single-family residential purposes (14.6% vs. 9.5%). However, the frequency (14.6%) was significantly smaller than the county average, 20.1%, suggesting that the transit impacts may exist beyond the half-mile circles.

Table 1 New Development Frequencies, 2001-2012

Category	Entire LA County	All Transit Areas	
		Near	Farther
Remained Vacant	72.8%	66.1%	71.3%
Converted to SF Residential	20.1%	9.5%	14.6%
Converted to MF Residential	1.6%	2.5%	0.9%
Converted to TCIU*	3.2%	19.7%	9.4%
Converted to Open Space	2.4%	2.2%	3.8%

* TCIU: Transportation, Communications, Industrial/Commercial, and Utility uses

Instead, a considerable proportion of the land parcels in these transit areas was converted to commercial and industrial properties. More specifically, 9.4% of the vacant parcels in Farther areas took this path of infill development, whereas commercial and industrial development accounts for only 3.2% in the county, as a whole. The comparable frequency of Near areas was 19.7%. Farther areas showed a 3.8% of Open Space development, which was higher than both the county average and that of Near areas. However, the frequency of Multi-family Residential development was lower than expected.

It is important to note that the development rates were particularly high around the stations opened before the Gold Line Phase-I. In the case of this sub-group, approximately 40% of the vacant parcels in Farther areas had experienced new development of any kind, while the rate of Near areas was 51.7% (Table 2). Although generally Near areas were more likely to be developed than Farther areas (33.9% vs. 28.7%), the Gold Line Phase I exhibited more rapid development in Farther areas (22.4%) than Near areas (16.5%).

Table 2 Detailed New Development Frequencies, 2001-2012

Category	Older Stations (pre-2003)		Gold Line Phase-I (2003)		Newer Stations (Post-2003)	
	Near	Farther	Near	Farther	Near	Farther
Remained Vacant	48.3%	59.5%	83.5%	77.6%	48.1%	77.9%
Converted to SF Residential	15.8%	15.4%	4.5%	15.0%	5.8%	2.9%
Converted to MF Residential	4.0%	1.1%	0.9%	0.8%	5.8%	0.7%
Converted to TCIU*	31.5%	22.7%	7.5%	1.7%	38.5%	8.1%
Converted to Open Space	0.5%	1.2%	3.6%	4.9%	1.9%	10.3%

* TCIU: Transportation, Communications, Industrial/Commercial, and Utility uses

Redevelopment of Industrial Sites

Farther areas, however, did not show a more rapid transformation in terms of redevelopment of industrial properties (Table 3). Although the gaps were generally negligible, the redevelopment frequencies in these areas were smaller than the county averages for all of the four categories. In terms of detailed composition, commercial development (i.e., converted to TCU) was somewhat dominant in both Near and Farther areas. This result is quite distinct from the new development case in which Single-family residential development showed a much higher rate in Farther areas.

Table 3 Redevelopment Frequencies, 2001-2012

Category	Entire LA County	All Transit Areas	
		Near	Farther
Remained Vacant	77.2%	78.2%	79.1%
Converted to SF Residential	1.7%	0.6%	0.9%
Converted to MF Residential	1.2%	0.8%	1.0%
Converted to TCU*	14.9%	16.2%	14.4%
Converted to Open Space	5.0%	4.1%	4.5%

* TCU: Transportation, Communications, Commercial, and Utility uses

One notable finding is a relatively higher level of redevelopment frequencies around the Gold Line Phase-I stations. Approximately 25% of the industrial parcels in the Gold Line Phase-I's Farther areas had undergone land use conversion between 2001 and 2012 (cf. County average 22.8%, All Near areas 21.8%, All Farther areas 20.9%). A majority of these parcels was found to be reused for transportation, communications, commercial, utilities and other public facilities.

Table 4 Detailed Redevelopment Frequencies, 2001-2012

Category	Older Stations (pre-2003)		Gold Line Phase-I (2003)		Newer Stations (Post-2003)	
	Near	Farther	Near	Farther	Near	Farther
Remained Vacant	79.1%	79.3%	74.8%	75.2%	77.1%	81.0%
Converted to SF Residential	0.9%	1.2%	0.2%	0.1%	0.0%	0.0%
Converted to MF Residential	0.9%	1.0%	2.1%	2.0%	0.2%	0.3%
Converted to TCU*	13.4%	13.0%	20.0%	21.1%	22.2%	18.0%
Converted to Open Space	5.8%	5.4%	3.0%	1.7%	0.4%	0.6%

* TCU: Transportation, Communications, Commercial, and Utility uses

Impacts of Transit Proximity on Land Use Change

While the frequency analysis presented above showed the distinct patterns of land use change in Near and Farther areas, it did not explain why such differences took place. A more rigorous examination is needed to check whether the detected land use change patterns can be attributed to the proximity to transit stations or other factors. Therefore, we estimated the impacts of the 0.5-1.0 mile transit proximity on land (re)development between 2001 and 2012, while controlling for the influences of many other determinants of urban land use change, by employing a multinomial logistic regression model, as done in our previous project (Kim and Houston, 2016).[3] The results suggest that the impacts of transit investments are not necessarily confined to the half-mile walking distance radius boundary. However, there is substantial variation among transit lines, indicating the importance of development history, local planning, and other factors that come into play.

[3] See Kim and Houston (2016) for a more detailed explanation about the model and the data used.

New Development Model

The tested variables, indicating parcels in Farther areas, showed a significant, positive impact on the probabilities of some types of new development. In particular, single-family residential and open space developments were found to be accelerated in broader vicinity areas. The coefficient patterns, however, were not uniform across stations/lines, as shown in Table 5. Please refer to Appendix for the detailed results.

Table 5 Impacts of Transit Proximity on New Development Probabilities, 2001-2012

Category	Older Stations (pre-2003)		Gold Line Phase-I (2003)		Newer Stations (Post-2003)	
	Near	Farther	Near	Farther	Near	Farther
1. SF Residential	(+)	(+)	(+)	(+)	(+)	Insig.
2. MF Residential	Insig.	(–)	(+)	(+)	(+)	Insig.
3. TCIU*	(+)	(+)	(+)	Insig.	(+)	(–)
4. Open Space	Insig.	Insig.	(+)	(+)	Insig.	(+)

* TCIU: Transportation, Communications, Industrial/Commercial, and Utility uses

Note: Insig. indicates that the effect is found to be not statistically significant at the 10% level.

In a few cases, the magnitude of the Farther variable's coefficient was larger than that of the Near variable. For instance, the positive impact of the Gold Line Phase-I's Farther variable on single-family residential development (+2.535) was slightly greater than that of the Gold Line Phase-I's Near variable (+2.217), suggesting that vacant parcels in the Farther areas could be converted to single-family housing more rapidly, all else being equal. A similar coefficient pattern was detected for commercial and industrial development around the older stations opened before the Gold Line Phase-I, as well as multi-family residential development around the Gold Line Phase-I stations.

The model results did not seem very sensitive to the inclusion of Farther variables. While Nbhd.MF% , one of the neighborhood land use composition variables, exhibited modest changes in its estimates, the estimated coefficient patterns for most other variables were found to be largely consistent (see Appendix for the detailed model estimation outcomes with and without Farther variables).

Redevelopment Model

In the case of the Gold Line Phase-I and older stations, Farther areas showed an increased probability of redevelopment for multi-family housing and open space. However, the newer stations' Farther variable showed no significant effect on the probability of the conversion of industrial properties to multi-family housing. Furthermore, it exhibited a significant, negative impact on the probability of redevelopment for open space, as shown in table 6.

Table 6 Impacts of Transit Proximity on Redevelopment Probabilities, 2001-2012

Category	Older Stations (pre-2003)		Gold Line Phase-I (2003)		Newer Stations (Post-2003)	
	Near	Farther	Near	Farther	Near	Farther
1. SF Residential	(–)	Insig.	Insig.	(–)	Insig.	Insig.
2. MF Residential	Insig.	(+)	(+)	(+)	(–)	Insig.
3. TCU	(–)	(–)	Insig.	Insig.	(+)	Insig.
4. Open Space	(+)	(+)	(+)	(+)	(–)	(–)

* TCU: Transportation, Communications, Commercial, and Utility uses
Note: Insig. indicates that the effect is found to be not statistically significant at the 10% level.

Around the Gold Line Phase I stations, the effects of Near and Farther area variables were largely consistent, although the coefficient magnitudes and significance levels were not identical. However, other lines had several cases in which Farther areas showed quite distinct impacts. These include the redevelopment for residential purposes around older stations and various types of redevelopment around the newer stations opened before the first phase of Metro's Gold Line. Again, the model results did not seem very sensitive to the inclusion of Farther area variables, while few control variables (e.g., population density) showed modest changes in their estimates on the probabilities of redevelopment for open space.

Policy Influences

To examine how other policies interacted with transit proximity and shaped urban land use change dynamics, we estimated the multinomial logistic model additionally with inclusion of some policy variables. More specifically, consideration was given to the following six policy instruments that were implemented to revitalize urban areas or promote development near transit stations.

- Federal Renewal Community Initiative (FRC): Introduced by the U.S. Department of Housing and Urban Development in 1993, this initiative aims to revitalize blighted communities by providing employment credits and tax exempts to qualified businesses in the designated areas.
- Federal Empowerment Zones (FEZ): The main goal of this program is to support highly distressed urban communities with federal grants and business tax credits. As noted in Kim and Houston (2016), many empowerment zones were located along the Blue and Gold lines in Los Angeles County.
- State Enterprise Zones (SEZ): This program attempts to promote business investment needed to revitalize declining areas, through business groups hiring credits, allowance of accelerated depreciation, and other incentives (Assembly Jobs, Economic Development, and the Economy Committee, 2010).
- Business Improvement Districts (BID): The City of Los Angeles implemented this program for economic development and marketing through more systematic public-private collaborations. "A business improvement district is a geographically defined area ... in

which services, activities and programs are paid for through a special assessment which is charged to all members within the district in order to equitably distribute the benefits received and the costs incurred to provide the agreed-upon services, activities and programs." (City of Los Angeles, n.d., http://clerk.lacity.org/business-improvement-districts/what-business-improvement-district)

- Targeted Neighborhood Initiative (TNI): This program is designed to promote capital improvements and housing rehabilitation and thus to revitalize marginal urban neighborhoods with Community Development Block Grants.
- Specific Plans for Transit-oriented development (Pro_SP): Many specific plans were implemented at the city-level to incentivize mixed use and compact development of the areas near transit stations. As briefly mentioned in Introduction, we identified these areas along with the Gold Line phase-I in the City of Los Angeles, the City of Pasadena, and the City of South Pasadena.

It should be noted that these policies were tested one by one. In doing so, we added two variables: Policy (indicating whether the land parcel was included in the policy boundaries or not) and a Policy×Transit interaction variable (indicating the parcels falling in both the policy boundaries and the half-mile circles of any transit stations).

Table 7 summarizes the estimation results of our redevelopment model. We focused on the redevelopment model results, because our new development models did not yield a reliable solution, when some of these policy variables were included.

Table 7 Policy and Combining Impacts, 2001-2012

	FRC	FRC×Transit	FEZ	FEZ×Transit	SEZ	SEZ×Transit
1. SF Residential	Insig.	Insig.	Insig.	Insig.	(–)	Insig.
2. MF Residential	Insig.	Insig.	(–)	Insig.	(–)	(+)
3. TCU	(+)	(–)	(–)	Insig.	(+)	(–)
4. Open Space	(+)	(–)	(–)	(–)	(–)	Insig.
	BID	BID×Transit	TNI	TNI×Transit	Pro_SP	Pro_SP×Transit
1. SF Residential	Insig.	Insig.	Insig.	Insig.	Insig.	Insig.
2. MF Residential	Insig.	(+)	Insig.	Insig.	(+)	Insig.
3. TCU	(+)	(–)	(+)	Insig.	(+)	Insig.
4. Open Space	Insig.	Insig.	(–)	(+)	Insig	Insig.

* TCU: Transportation, Communications, Commercial, and Utility uses
Note: Insig. indicates that the effect is found to be not statistically significant at the 10% level.

As shown in the table, FEZ was found to have a deterrent impact on the conversion of industrial sites to other uses. This result may suggest that the policy might contribute to keeping industrial activities with tax incentives. Unlike FEZ, FRC appeared to accelerate the conversion of industrial properties to some non-residential purposes, including open space. However, FRC×Transit interaction variable showed a significant impact with an opposite sign, suggesting that industrial properties within the policy boundaries were less likely to experience conversion to other land uses when located near transit stations.

SEZ, BID, and TNI were found to accelerate the conversion of industrial sites to transportation, communications, commercial or utility uses. However, similar to the case of FRC, the Policy×Transit interaction variables exhibited an opposite sign, indicating the policy's impacts differed in and outside of transit areas. Moreover, SEZ seemed to suppress the conversion of industrial sites to residential or open space purposes. Similarly, TNI showed a negative impact on the probability of conversion to open spaces, even though such an impact disappeared in near transit locations. However, TNI showed no deterrent impact on the conversion to residential purposes. This finding may be associated with TNI's emphasis on housing rehabilitation and the quality of life in neighborhoods.

Most notably, Pro_SP was found to promote the redevelopment of industrial properties for multi-family residential and commercial purposes. This finding suggests that local planning efforts can make a difference. For instance, near the Sierra Madre Villa station, a considerable number of industrial parcels were found to be converted to other land uses. These conversions seemed to be supported by the East Pasadena Specific Plan and the East Colorado Specific Plan (which covered the eastern portion of the station area) in which emphasis was placed on mixed and high-density development. The East Pasadena Specific Plan included a recommendation to rezone some parcels from industrial to office or R&D spaces, while recognizing the importance of the area as an industrial district.

Summary and Discussion

Recent years have witnessed a growing interest in transit-oriented development (TOD) and other transit-centered initiatives. However, we have often used the well-known half-mile circles around transit stations in delineating the potential impact area with little attention paid to what can be achieved beyond the half-mile radius boundary. In this study, we challenged this rigid delineation of transit areas and investigated land use change dynamics in broader vicinity areas. Some recent studies have reported that compactness, land use mix, better connectivity, and pedestrian-friendly designs can increase walking distances (or catchment area) around transit stations (see e.g., Guerra et al. 2012; Petheram et al. 2013; Zhao and Deng 2013; Flamm and Rivasplata 2014; Jun et al. 2015; Kwoka et al. 2015). These factors, in turn, can induce a favorable use of land areas surrounding transit stations more broadly.

We found that the land use impacts of transit investments were not necessarily confined to the half-mile walking distance radius boundary, while the impacts substantially varied by transit line. For instance, 66% of vacant parcels near stations (<0.5 miles) experienced no conversion between 2001 and 2012, compared to 71% for areas farther from stations (0.5-1.0 miles) and 73% for the county as a whole. Less than 10% of the vacant parcels in Near areas were converted to single-family residential use, compared to 15% for Farther areas and 20% for the county as a whole. In comparison, nearly 20% of Near-station vacant parcels were converted to commercial or industrial use, compared to 9% for Farther areas and 3% for the county as a whole.

Our multinomial logit analysis results also confirmed that transit investments could generate noticeable impacts not only on the parcels immediately adjacent to transit stations but also the areas beyond the half-mile radius. Among others, vacant parcels in Farther areas were found to be more rapidly developed for single-family residential and open space purposes. Regarding redevelopment of industrial properties, our results are less conclusive. While the Farther areas around the Gold Line Phase-I and older stations showed an increased probability of redevelopment for multi-family housing, such impacts were not detected around newer stations. It was also found that industrial sites were less likely to be reused for single-family housing.

Finally, it should be stressed that local policy/planning efforts can make a difference in inducing a more sustainable form of urban land use. Although there is no doubt that policy outcomes are context-sensitive, local specific plans that encouraged transit-oriented development seemed to promote the redevelopment of old industrial sites for multi-family residential and commercial purposes. Local planners and policy makers should recognize the importance of their actions. It is also important to think beyond the traditional half-mile circles and refine their strategies for directing growth into broader vicinity areas. This will eventually enable us to attain the full vision of Senate Bill 375 and other sustainable development initiatives through sensible transportation investment decision-making and its integration with local land use planning.

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Appendix. Logistic Regression Results

New development model

Variables	(1) Single-family Residential	(2) Multi-family Residential	(3) TCIU	(4) Open Space
Intercept	-19.955 ***	-17.545 ***	-12.900 ***	-12.641 ***
Gold.First.Near	2.217 ***	2.144 ***	1.339 ***	3.423 ***
Gold.First.Farther	2.535 ***	2.739 ***	0.013	1.898 ***
Before.GoldFirst.Near	0.515 ***	0.131	0.389 ***	-0.064
Before.GoldFirst.Farther	0.744 ***	-0.548 *	0.759 ***	-0.318
After.GoldFirst.Near	0.064	1.808 ***	0.922 ***	0.923
After.GoldFirst.Farther	-0.758	0.618	-0.776 **	0.864 ***
Low.Ridership.Near	-2.534 ***	-29.120	-0.450	-2.999 ***
Low.Ridership.Farther	-1.512 ***	-41.760	0.140	-0.597 **
ln.Parcel.Size	-0.679 ***	-0.564 ***	0.212 ***	0.642 ***
Parcel.Shape	11.066 ***	8.433 ***	-0.460 *	-4.280 ***
Parcel.Slope	-0.028 ***	-0.062 ***	-0.058 ***	0.045 ***
ln.Nbhd.Med.Income	1.594 ***	0.992 ***	0.615 ***	0.142 **
Nbhd.Education	-1.484 ***	1.204 ***	0.181	0.021
Nbhd.Pop.Density	0.00010 ***	0.00015 ***	0.00013 ***	0.00030 ***
Nbhd.Road.Density	0.026 ***	0.052 ***	0.009 ***	-0.037 ***
Dist.CBD	0.162 ***	0.328 ***	0.104 ***	0.065 ***
Dist.CBD.Squared	-0.00152 ***	-0.00420 ***	-0.00144 ***	-0.00079 ***
Nbhd.SF%	2.256 ***	0.281 **	1.200 ***	1.590 ***
Nbhd.MF%	-0.114	1.027 ***	1.239 ***	0.727
Nbhd.CI%	1.321 ***	2.003 ***	3.218 ***	-0.505 **
Nbhd.OS%	3.272 ***	-0.761	3.146 ***	6.173 ***
Under.Construction	2.210 ***	1.965 ***	1.560 ***	0.646 ***

*** 1% level, ** 5% level, * 10% level significant; sample size = 182,173; pseudo r-squared: 0.360

New development model *without Farther variables* (source: Kim and Houston, 2016)

Variables	(1) Single-family Residential	(2) Multi-family Residential	(3) TCIU	(4) Open Space
Intercept	-19.410 ***	-17.242 ***	-12.796 ***	-12.096 ***
Gold.First.Near	1.964 ***	2.007 ***	1.215 ***	3.162 ***
Before.GoldFirst.Near	0.377 **	0.120	0.289 **	-0.173
After.GoldFirst.Near	0.401	2.120 ***	0.700 **	1.136
Low.Ridership.Near	-2.516 ***	-35.191	-0.449	-3.023 ***
ln.Parcel.Size	-0.681 ***	-0.566 ***	0.211 ***	0.638 ***
Parcel.Shape	10.995 ***	8.457 ***	-0.472 *	-4.271 ***
Parcel.Slope	-0.029 ***	-0.062 ***	-0.059 ***	0.045 ***
ln.Nbhd.Med.Income	1.580 ***	0.984 ***	0.615 ***	0.130 *
Nbhd.Education	-1.563 ***	1.114 ***	0.230	-0.208
Nbhd.Pop.Density	0.00011 ***	0.00014 ***	0.00015 ***	0.00030 ***
Nbhd.Road.Density	0.025 ***	0.050 ***	0.010 ***	-0.038 ***
Dist.CBD	0.150 ***	0.322 ***	0.100 ***	0.054 ***
Dist.CBD.Squared	-0.00142 ***	-0.00416 ***	-0.00141 ***	-0.00069 ***
Nbhd.SF%	2.218 ***	0.328 **	1.116 ***	1.576 ***
Nbhd.MF%	0.252	1.413 ***	1.087 ***	1.006 *
Nbhd.CI%	1.215 ***	1.940 ***	3.200 ***	-0.486 **
Nbhd.OS%	3.226 ***	-0.776 *	3.083 ***	6.234 ***
Under.Construction	2.247 ***	2.011 ***	1.585 ***	0.654 ***

*** 1% level, ** 5% level, * 10% level significant; sample size = 182,173; pseudo r-squared: 0.358

Redevelopment model

Variables	(1) Single-family Residential	(2) Multi-family Residential	(3) TCU	(4) Open Space
Intercept	-4.908 ***	-8.320 ***	-1.061 ***	-5.755 ***
Gold.First.Near	-1.626	1.381 ***	0.025	0.897 ***
Gold.First.Farther	-1.742 *	1.376 ***	-0.013	0.566 *
Before.GoldFirst.Near	-0.582 ***	0.300	-0.164 ***	1.048 ***
Before.GoldFirst.Farther	0.198	0.297 **	-0.140 ***	0.842 ***
After.GoldFirst.Near	-16.021	-1.383 **	0.301 ***	-1.342 ***
After.GoldFirst.Farther	-16.249	-0.497	0.122	-1.283 ***
Low.Ridership.Near	-15.063	-16.865	0.194	-16.835
Low.Ridership.Farther	-14.062	1.209 **	0.166	0.113
ln.Parcel.Size	-0.759 ***	-0.449 ***	0.088 ***	-0.375 ***
Parcel.Shape	8.450 ***	2.604 ***	-3.461 ***	-8.236 ***
Parcel.Slope	0.167 ***	-0.005	-0.040 ***	0.112 ***
ln.Nbhd.Med.Income	0.060	0.381 ***	-0.097 ***	0.387 ***
Nbhd.Education	-1.122 ***	2.945 ***	0.889 ***	-0.137
Nbhd.Pop.Density	-0.00019 ***	0.00006 **	-0.00003 ***	0.00002
Nbhd.Road.Density	0.046 ***	0.004	0.001	0.015 ***
Dist.CBD	0.140 ***	0.131 ***	-0.010 ***	0.150 ***
Dist.CBD.Squared	-0.00181 ***	-0.00169 ***	0.00018 ***	-0.00161 ***
Nbhd.SF%	2.370 ***	0.627 **	0.909 ***	-0.446 ***
Nbhd.MF%	3.075 ***	2.216 ***	2.625 ***	0.336
Nbhd.CI%	2.823 ***	0.350	1.150 ***	0.606 ***
Nbhd.OS%	0.534	-0.480	-0.293 **	0.339 **

*** 1% level, ** 5% level, * 10% level significant; sample size = 51,893; pseudo r-squared: 0.097

Redevelopment model *without Farther variables* (source: Kim and Houston, 2016)

Variables	(1) Single-family Residential	(2) Multi-family Residential	(3) TCU	(4) Open Space
Intercept	-5.300 ***	-7.801 ***	-1.116 ***	-5.683 ***
Gold.First.Near	-1.700 *	1.444 ***	0.088	0.797 ***
Before.GoldFirst.Near	-0.575 ***	0.192	-0.136 **	0.891 ***
After.GoldFirst.Near	-14.693	-1.190 **	0.302 ***	-1.354 ***
Low.Ridership.Near	-13.531	-15.731	0.150	-15.616
ln.Parcel.Size	-0.759 ***	-0.450 ***	0.088 ***	-0.377 ***
Parcel.Shape	8.462 ***	2.668 ***	-3.479 ***	-8.21 ***
Parcel.Slope	0.165 ***	-0.004	-0.039 ***	0.111 ***
ln.Nbhd.Med.Income	0.087	0.349 ***	-0.095 ***	0.398 ***
Nbhd.Education	-1.248 ***	3.081 ***	0.852 ***	-0.085
Nbhd.Pop.Density	-0.00018 ***	0.00006 **	-0.00004 ***	0.00004 **
Nbhd.Road.Density	0.046 ***	0.004	0.001	0.019 ***
Dist.CBD	0.149 ***	0.120 ***	-0.009 ***	0.145 ***
Dist.CBD.Squared	-0.00191 ***	-0.00155 ***	0.00017 ***	-0.00157 ***
Nbhd.SF%	2.331 ***	0.627 **	0.938 ***	-0.663 ***
Nbhd.MF%	2.966 ***	2.104 ***	2.694 ***	-0.257
Nbhd.CI%	2.781 ***	0.365	1.172 ***	0.499 ***
Nbhd.OS%	0.489	-0.548	-0.276 **	0.234

*** 1% level, ** 5% level, * 10% level significant; sample size: 51,893; pseudo r-squared: 0.094